Geographic Information Science

Department Website: https://voices.uchicago.edu/giscience

PROGRAM OF STUDY

Spatial thinking deals with the fundamental role of space, place, location, distance, and interaction—crucial to tackling many research questions in the social and physical sciences. The minor in geographic information science provides a coherent exposure to rigorous spatial thinking and its expression through the theories and methods of geographic information science.

Geographic information science covers all aspects pertaining to accessing, storing, transforming, manipulating, visualizing, exploring, and reasoning about information where the locational component is important (spatial data). This includes the technical and computational aspects of geographic information systems, the methodologies of spatial analysis and spatial statistics, mapping, and geo-visualization, as well as societal aspects related to the use of geographic data.

The minor serves as a complement to other majors, such as computer science, statistics, economics, public policy studies, sociology, anthropology, political science, or environmental and urban studies, but would also be of value to majors in the humanities and physical sciences interested in the spatial aspects of their field.

PROGRAM REQUIREMENTS FOR THE MINOR

The minor consists of six courses: two prerequisites, three core methods courses, and one elective from a series of offerings. The core methods courses provide a coherent exposure to rigorous spatial thinking and its incorporation into the methodologies of geographic information systems, spatial analysis, and spatial data science.

The electives consist of courses that touch upon various aspects of spatial thinking, with different degrees of technical materials, and are intended to either act as “gateways” into the minor or to provide the opportunity for the application of spatial analysis in a range of fields.

GIScience Practicum serves as an optional capstone course for the minor. In the course, students will develop a multifaceted GIS project incorporating spatial thinking in design, infrastructure, and implementation. Projects could include the development of a web application, dynamic dashboard, interactive storytelling map, infographic-driven policy brief, or research article and can be carried out in conjunction with a thesis requirement of the student’s major.

SUMMARY OF REQUIREMENTS: MINOR IN GEOGRAPHIC INFORMATION SCIENCE

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT 22000</td>
<td>Statistical Methods and Applications (or equivalent)</td>
<td>100</td>
</tr>
<tr>
<td>or DATA 11800</td>
<td>Introduction to Data Science I</td>
<td>100</td>
</tr>
<tr>
<td>GISC 28702</td>
<td>Introduction to GIS and Spatial Analysis (or equivalent introductory GIS course (by petition))</td>
<td>100</td>
</tr>
<tr>
<td>Three core methods courses from the approved list</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Any elective from the list of courses below</td>
<td>100</td>
<td></td>
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<tr>
<td>Total Units</td>
<td></td>
<td>600</td>
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* Students who take STAT 22000 or DATA 11800 to satisfy a major requirement will complete a five-course (500-unit) minor.

CORE METHODS OPTIONS FOR THE MINOR IN GEOGRAPHIC INFORMATION SCIENCE

Three of the following courses must be taken to fulfill the core methods requirement for the minor in geographic information science.

<table>
<thead>
<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>GISC 20500</td>
<td>Introduction to Spatial Data Science</td>
<td>100</td>
</tr>
<tr>
<td>GISC 27100</td>
<td>Cartographic Design and Geovisualization</td>
<td>100</td>
</tr>
<tr>
<td>GISC 28100</td>
<td>Introduction to Geocomputation</td>
<td>100</td>
</tr>
<tr>
<td>GISC 28200</td>
<td>Spatial Analysis Methods in Geographic Information Systems</td>
<td>100</td>
</tr>
<tr>
<td>GISC 28300</td>
<td>Topics in Geographic Information Science</td>
<td>100</td>
</tr>
<tr>
<td>GISC 28400</td>
<td>GIScience Practicum</td>
<td>100</td>
</tr>
</tbody>
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ELECTIVE OPTIONS FOR THE MINOR IN GEOGRAPHIC INFORMATION SCIENCE

A fourth core methods course or one of the following courses may be taken to fulfill the elective course option for the minor in geographic information science. Course availability varies by year.

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Units</th>
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</thead>
<tbody>
<tr>
<td>GISC 20273</td>
<td>Urban Spatial Archaeology I</td>
<td>100</td>
</tr>
<tr>
<td>GISC 20519</td>
<td>Spatial Cluster Analysis</td>
<td>100</td>
</tr>
<tr>
<td>GISC 25900</td>
<td>Introduction to Location Analysis</td>
<td>100</td>
</tr>
</tbody>
</table>
GISC 27102  Spatial Cognition  100
GISC 28700  Readings in Spatial Analysis  100
GISC 28800  History of Cartography  100
GISC 29000  Reading/Research: Geographic Information Sciences  100

ADVISING AND GRADING
Courses in the minor may not be double-counted with the student's major(s), other minors, or general education requirements.

Courses in the minor must be taken for quality grades, and more than half of the requirements for the minor must be met by registering for courses bearing University of Chicago course numbers.

Students who elect the minor must confer with the program before the end of Spring Quarter of their third year to declare their intention to complete the minor. The director's approval for the minor program should be submitted to the student's College adviser by the deadline above using the Consent to Complete a Minor Program (https://humanities-web.s3.us-east-2.amazonaws.com/college-prod/s3fs-public/documents/Consent_Minor_Program.pdf) form.

Students may petition the program to have a course counted as an elective that is not included on the current list of electives.

GEOGRAPHIC INFORMATION SYSTEM COURSES
GISC 20061. Ancient Landscapes I. 100 Units.
This is a two-course sequence that introduces students to theory and method in landscape studies and the use of Geographical Information Systems (GIS) to analyze archaeological, anthropological, historical, and environmental data. Course one covers the theoretical and methodological background necessary to understand spatial approaches to landscape and the fundamentals of using ESRI’s ArcGIS software, and further guides students in developing a research proposal. Course two covers more advanced GIS-based analysis (using vector, raster, and satellite remote sensing data) and guides students in carrying out their own spatial research project.
In both courses, techniques are introduced through the discussion of case studies (focused on the archaeology of the Middle East) and through demonstration of software skills. During supervised laboratory times, the various techniques and analyses covered will be applied to sample archaeological data and also to data from a region/topic chosen by the student.
Equivalent Course(s): ANTH 36710, CEGU 20061, NEAA 30061, GISC 30061, ANTH 26710, CEGU 30061, NEAA 20061

GISC 20062. Ancient Landscapes II. 100 Units.
This is a two-course sequence that introduces students to theory and method in landscape studies and the use of Geographical Information Systems (GIS) to analyze archaeological, anthropological, historical, and environmental data. Course one covers the theoretical and methodological background necessary to understand spatial approaches to landscape and the fundamentals of using ESRI’s ArcGIS software, and further guides students in developing a research proposal. Course two covers more advanced GIS-based analysis (using vector, raster, and satellite remote sensing data) and guides students in carrying out their own spatial research project.
In both courses, techniques are introduced through the discussion of case studies (focused on the archaeology of the Middle East) and through demonstration of software skills. During supervised laboratory times, the various techniques and analyses covered will be applied to sample archaeological data and also to data from a region/topic chosen by the student.
Equivalent Course(s): NEAA 20062, ANTH 26711, ANTH 36711, CEGU 20062, NEAA 30062, GISC 30062, CEGU 30062

GISC 20273. Urban Spatial Archaeology I. 100 Units.
Space and time are fundamental concepts in urban spatial science. In this course, students will gain substantive and technical knowledge on how to analyze space and time through the tools of urban spatial archaeology. Specifically, this course will introduce students to various historical data sources on Chicago and New Orleans to digitize, then conduct a spatial historical analysis of any topic of their choice. By taking a historical approach to the study of time and space, students will walk away from the course with (1) ways to conceptualize time and space when studying urban issues, and (2) skills for designing a project to empirically demonstrate the workings of time and space in the real world. At the end of this course, students will be expected to have produced a historical dataset for a research paper that will be completed in the next course sequence.
Equivalent Course(s): SOCI 30273, GISC 30273, SOCI 20273

GISC 20500. Introduction to Spatial Data Science. 100 Units.
Spatial data science consists of a collection of concepts and methods drawn from both statistics and computer science that deal with accessing, manipulating, visualizing, exploring and reasoning about geographical data. The course introduces the types of spatial data relevant in social science inquiry and reviews a range of methods to explore these data. Topics covered include formal spatial data structures, geovisualization and visual analytics, rate smoothing, spatial autocorrelation, cluster detection and spatial data mining. An important aspect of the course is to learn and apply open source GeoDa software.
Equivalent Course(s): CEGU 20253, GISC 30500, ENST 20253, SOCI 20253, MACS 54000, SOCI 30253

GISC 20519. Spatial Cluster Analysis. 100 Units.

This course provides an overview of methods to identify interesting patterns in geographic data, so-called spatial clusters. Cluster concepts come in many different forms and can generally be differentiated between the search for interesting locations and the grouping of similar locations. The first category consists of the identification of extreme concentrations of locations (events), such as hot spots of crime events, and the location of geographical concentrations of observations with similar values for one or more variables, such as areas with elevated disease incidence. The second group consists of the combination of spatial observations into larger (aggregate) areas such that internal similarity is maximized (regionalization). The methods covered come from the fields of spatial statistics as well as machine learning (unsupervised learning) and operations research. Topics include point pattern analysis, spatial scan statistics, local spatial autocorrelation, dimension reduction, as well as spatially explicit hierarchical, agglomerative and density-based clustering. Applications range from criminology and public health to politics and marketing. An important aspect of the course is the analysis of actual data sets by means of open source software, such as GeoDa, R or Python.

Equivalent Course(s): ENST 20519, SOCI 20519, GISC 30519, SOCI 30519, MACS 30519

GISC 20559. Spatial Regression Analysis. 100 Units.

This course covers statistical and econometric methods specifically geared to the problems of spatial dependence and spatial heterogeneity in cross-sectional data. The main objective for the course is to gain insight into the scope of spatial regression methods, to be able to apply them in an empirical setting, and to properly interpret the results of spatial regression analysis. While the focus is on spatial aspects, the types of methods covered have general validity in statistical practice. The course covers the specification of spatial regression models in order to incorporate spatial dependence and spatial heterogeneity, as well as different estimation methods and specification tests to detect the presence of spatial autocorrelation and spatial heterogeneity. Special attention is paid to the application to spatial models of generic statistical paradigms, such as Maximum Likelihood and Generalized Methods of Moments. An import aspect of the course is the application of open source software tools such as various R packages, GeoDa and the Python Package PySal to solve empirical problems.

Equivalent Course(s): GISC 30559, SOCI 20559, SOCI 30559

GISC 24600. Introduction to Urban Sciences. 100 Units.

This course is a grand tour of conceptual frameworks, general phenomena, emerging data and policy applications that define a growing scientific integrated understanding of cities and urbanization. It starts with a general outlook of current worldwide explosive urbanization and associated changes in social, economic and environmental indicators. It then introduces a number of historical models, from sociology, economics and geography that have been proposed to understand how cities operate. We will discuss how these and other facets of cities can be integrated as dynamical complex systems and derive their general characteristics as social networks embedded in structured physical spaces. Resulting general properties of cities will be illustrated in different geographic and historical contexts, including an understanding of urban resource flows, emergent institutions and the division of labor and knowledge as drivers of innovation and economic growth. The second part of the course will deal with issues of inequality, heterogeneity and (sustainable) growth in cities. We will explore how these features of cities present different realities and opportunities to different individuals and how these appear as spatially concentrated (dis)advantage that shape people’s life courses. We will show how issues of inequality also have consequences at more macroscopic levels and derive the general features of population and economic growth for systems of cities and nations.

Equivalent Course(s): CEGU 24600, SOCI 20285, PBPL 24605, GISC 34600, ENST 24600

GISC 24700. Introduction to Urban Planning. 100 Units.

The academic study of urban planning encompasses a range of issues dealing with cities, from urban design to governance, economic development, local politics, and place. The goal of this course is to provide a broad overview of urban planning theory and history while at the same time introducing students to basic GIS applications for urban planners. This format provides students with a better contextual understanding of the wide range of issues currently facing 21st century cities, and at the same time serves as an introduction to the everyday practice of urban planning. The course includes readings from prominent urban theorists, a discussion of the historical development of the urban planning profession in the US, and GIS exercises that allow students to apply their theoretical urban knowledge to real-world planning problems.

Equivalent Course(s): ENST 24680, GISC 34700

GISC 25900. Introduction to Location Analysis. 100 Units.

Understanding the location of business activities - agricultural, industrial, retail, and knowledge-based - has long been a focus for economic geographers, regional scientists, and urban planners. This course traces the key theories and conceptual models that have been developed over time to explain why economic activities tend to locate where they do. To introduce and explain these theories, this course covers several foundational concepts in economic geography and urban planning, such as: bid-rent theory, locational triangulation, various models of urban structure and growth, urban market areas, transportation, economic restructuring, and the "back-to-the-city" movement. This course incorporates several GIS exercises to teach students the basic principles of location optimization and to help illuminate the foundational theoretical principles of economic geography.

Equivalent Course(s): GISC 35900, ENST 25910
GISC 26006. Sustainable Cities Lab. 100 Units.
The Sustainable Cities Lab will provide the opportunity to learn and utilize urban design tools while competing in a global sustainability competition to design green and thriving city neighborhoods that work to reduce greenhouse gas emissions, and improve quality of life for local communities. Students will apply their skills to create an entry for the Students Reinventing Cities competition (https://www.c40reinventingcities.org/en/students/). The course will support student development of knowledge and skills related to this competition, focusing on applications of urban design and sustainable urbanism concepts and principles. Various workshops will be utilized for training in design tools, graphics, data visualization, and other methods necessary to create a winning entry. Basic knowledge of GIS or comparable skill in graphic design or illustration is required. Equivalent Course(s): ENST 26006, CHST 26006

GISC 27100. Cartographic Design and Geovisualization. 100 Units.
This course is a hands-on introduction to core principles and techniques associated with cartographic design, especially with regards to digital map design and the geographic visualization of data. Main topics include map generalization, symbology, scale, visual variables, scales of measurement, 2D and 3D design, map animation and interaction, and web mapping. Students will work with open-source GIS software and web tools, culminating in a final project and peer critique. Equivalent Course(s): CHST 27100, ENST 27111, GISC 37100, CEGU 27100

GISC 27102. Spatial Cognition. 100 Units.
This course serves as an overview of spatial cognition and environmental perception, which relates to all aspects of spatial thinking, spatial behavior, and human-environment interaction in spatial and social contexts. Topics of study include cognitive maps and wayfinding behavior, spatial and environmental learning, spatial choice and decision-making, migration and travel, time geography, place and regional identity, and the role of gender and culture in spatial cognition. Equivalent Course(s): GISC 37102, ENST 28722, CHST 27102

GISC 27104. Movement Data and Analysis. 100 Units.
This is a methodological course overviewing movement data types, common data sources and applications, movement representations and scale, movement parameters, 2D and 3D representations of movement, and types of visualization approaches (trajectories, flow maps, network-based). The topics covered draw from application areas in human transportation, temporary travel and migration, and non-human animal movement. Equivalent Course(s): GISC 37104

GISC 27105. Web Mapping. 100 Units.
This course will provide an introduction to Internet-based Geographic Information Systems (GIS) and web cartography. Students will develop proficiency with programming concepts underlying the creation and implementation of quality web mapping applications through hands-on experience creating applications with popular web mapping platforms such as Leaflet and ArcGIS Maps SDK for JavaScript. Equivalent Course(s): GISC 37105

GISC 27110. Spatial Thinking in Historical Cartography. 100 Units.
The course will introduce students to the ways in which cartographers in the English-speaking world have conceived of representing spatial patterns in map form, and how that has changed over time beginning in the 18th century, given changes in world view, cultural background, cartographic technology, business organization, and educational fashion. The objective is to sharpen students' ability to think critically about how maps have been produced in history, evaluate their design, effectiveness, and limitations, and the uses to which they have been put. Equivalent Course(s): CEGU 27110, ENST 27110, CHST 27110

GISC 27115. Urban Design with Nature. 100 Units.
This course will use the Chicago region as the setting to evaluate the social, environmental, and economic effects of alternative forms of human settlement. Students will examine the history, theory and practice of designing cities in sustainable ways - i.e., human settlements that are socially just, economically viable, and environmentally sound. Students will explore the literature on sustainable urban design from a variety of perspectives, and then focus on how sustainability theories play out in the Chicago region. How can Chicago's neighborhoods be designed to promote environmental, social, and economic sustainability goals? This course is part of the College Course Cluster program: Urban Design. Equivalent Course(s): CHST 27155, BPRO 27155, PBPL 27156, CEGU 27155

GISC 28100. Introduction to Geocomputation. 100 Units.
This course investigates the theory and practice of infrastructure and computational approaches in Geographic Information Science. Geocomputation is introduced as a multidisciplinary systems paradigm necessary for solving complex spatial problems and facilitating new understandings. Students will learn about the elements of spatial algorithms and data structures, geospatial topologies, spatial data queries, the basics of geodatabase architecture and design, and their implementation in open source software, such as R or Python. Equivalent Course(s): ARCH 28202, GISC 38100

GISC 28200. Spatial Analysis Methods in Geographic Information Systems. 100 Units.
This course provides an overview of methods of spatial analysis and their implementation in geographic information systems. These methods deal with the retrieval, storage, manipulation and transformation of spatial
data to create new knowledge. Examples are spatial join operations, spatial overlay, buffering, measuring accessibility, network analysis and raster operations. The fundamental principles behind the methods are covered as well as their application to real-life problems using open source software such as QGIS.

Equivalent Course(s): ARCH 28402, GISC 38200

**GISC 28300. Topics in Geographic Information Science. 100 Units.**
This advanced course extends and connects both foundational and functional concepts in Geographic Information Science. Topics will vary, but include GIS customization, enterprise GIS, web GIS, and advanced visualization and analytic techniques. In addition to an in-depth coverage of the foundational topics, students will be introduced to their implementation in open source software environments through advanced programming and scripting languages.

Equivalent Course(s): GISC 38300, ARCH 28602

**GISC 28400. GIScience Practicum. 100 Units.**
This applied course in geographic information science builds upon and refines knowledge and geocomputational expertise gained in the GIScience sequence. Students will develop multifaceted GIS project incorporating spatial thinking in design, infrastructure, and implementation. Projects could include the development of a web application, dynamic dashboard, interactive storytelling map, infographic-driven policy brief, or research article and are encouraged to link additional disciplines like health, sociology, economics, or political science.

Equivalent Course(s): GISC 38400

**GISC 28700. Readings in Spatial Analysis. 100 Units.**
This independent reading option is an opportunity to explore special topics in the exploration, visualization and statistical modeling of geospatial data.

Equivalent Course(s): ENST 28800, GISC 38700

**GISC 28702. Introduction to GIS and Spatial Analysis. 100 Units.**
This course provides an introduction and overview of how spatial thinking is translated into specific methods to handle geographic information and the statistical analysis of such information. This is not a course to learn a specific GIS software program, but the goal is to learn how to think about spatial aspects of research questions, as they pertain to how the data are collected, organized and transformed, and how these spatial aspects affect statistical methods. The focus is on research questions relevant in the social sciences, which inspires the selection of the particular methods that are covered. Examples include spatial data integration (spatial join), transformations between different spatial scales (overlay), the computation of “spatial” variables (distance, buffer, shortest path), geovisualization, visual analytics, and the assessment of spatial autocorrelation (the lack of independence among spatial variables). The methods will be illustrated by means of open source software such as QGIS and R.

Equivalent Course(s): CEGU 28702, ENST 28702, ARCH 28702, PPHA 38712, SOCI 30283, GISC 38702, SOCI 20283

**GISC 28800. History of Cartography. 100 Units.**
This course offers a grand overview of the key developments in mapmaking throughout history worldwide, from pre-literate cartography to the modern interactive digital environment. It looks at the producers, their audience, the technologies and artistic systems used, and the human and global contexts in which they developed. The course also draws on the extensive map collections of Regenstein Library.

Equivalent Course(s): GISC 38800, CHST 28800, ARCH 28800

**GISC 29000. Reading/Research: Geographic Information Sciences. 100 Units.**
Independent study for graduate students interested in Geographic Information Sciences (GIS). Students and instructors can arrange a Reading/Research course when the material being studied goes beyond the scope of a particular course, when students are working on material not covered in an existing course, or when students would like to receive academic credit for independent research. Subject, course of study, and requirements must be arranged with the instructor.

Equivalent Course(s): GISC 49000